

Linear Referencing Systems and GPS Mainline Inventory



Washington State
Department of Transportation

Linear Referencing Methods

- a way to identify a specific location with respect to a known point
- methods used include milepost, accumulated route mileage, geographic coordinates, or GPS coordinates
- the common methods used in WSDOT are based on state route milepost (SRMP) and accumulated route mileage (ARM)

A Linear Referencing System (LRS) is...

- the set of field and office procedures that builds and maintains one or more linear referencing methods

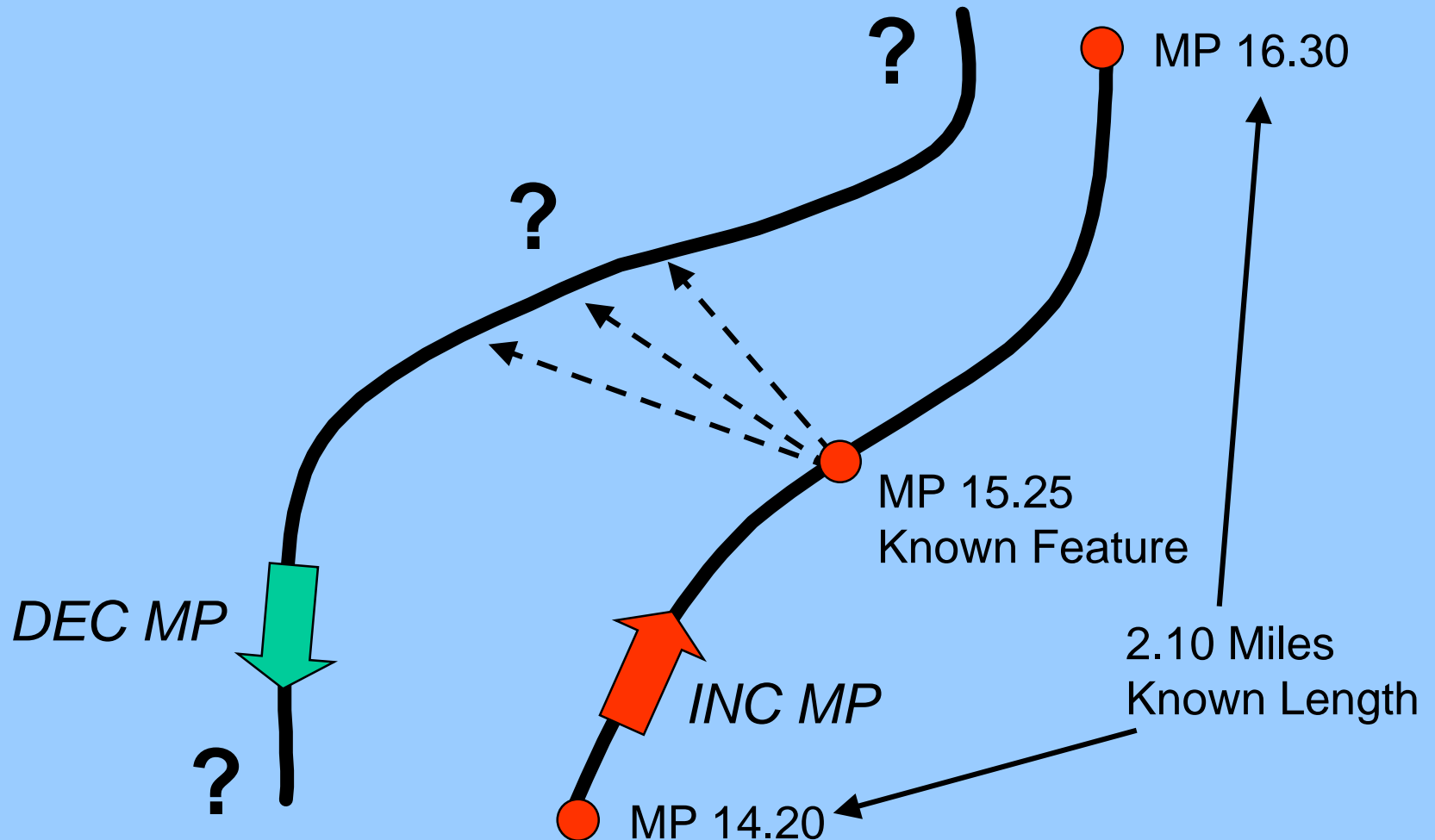
Current LRS

- Method used in TRIPS/TARIS to locate state route features, accidents and traffic volumes
- Based on Accumulated Route Mileage (ARM) and State Route Milepost (SRMP)

Problems with Current LRS

- Roadway locations and lengths are based on increasing milepost direction only
- Accuracy +/- 52.8 feet is less than GIS
- GIS data often cannot be located correctly on divided highways, due to offset distance between increasing and decreasing milepost sides of the highway

Divided Highway Offset with Current LRS



Seeking Solutions

- based on customer needs identified in 1996, a more accurate method to locate roadside features on the more than 7,000 miles of Washington State Highways was required
- this led to the ROAD project

Roadway Object & Attribute Data (ROAD)

- utilizes WSDOT's Linear Referencing System (LRS) and Global Positioning System (GPS) to locate specific roadside features and their attributes
- pilot project conducted in 1998-99

Feature data collection begins and....

- the accuracy of the roadside feature data was at a ***higher level of precision*** (3-5 feet) than existing LRS or GIS layers could accommodate
- recognition that existing GIS representations of State Routes, which were based on U.S. Geological Survey quadrangle maps, were inadequate for the new data

The proposal....

- develop new State Route GIS layers using GPS data
- inventory each State Route's mainline in ***both directions***
- create a geo-spatial representation of the State Route with sub-meter accuracy

Challenges encountered....

- due to overhanging trees, buildings and other obstructions, “gaps” developed in the GPS data as it was being collected
- these gaps degraded the accuracy of the mainline inventory
- an auxiliary data collection system based on inertial movement was needed to supplement the GPS data

The result.... development of the GPS Mainline Inventory

- combines GPS and Inertial Navigation data
- creates a GIS “Roadtrack”, a cartographic representation for both directions of a State Route with sub-meter accuracy
- 10 State Routes initially selected for the inventory

Data Collection Methods

- Mainline Inventory Van
- Manual Collection
- Remote Acquisition

GPS Mainline Inventory Van

- mobile office equipped for GPS (Trimble) & Inertial Navigation (Navstar) data collection
- contains two computer systems, GPS receiver, auxiliary data processor, heading gyro, altimeter, and distance measuring instrument

GPS Mainline Inventory Van

- simultaneously collects GPS and Inertial Navigation data
- creates and stores data files for later office processing
- performs inventory in both directions of State Route from ***innermost*** lanes

Manual Collection

- portable GPS receiver used to collect XYZ coordinates for begin and end points of State Routes or portions of State Routes
- begin and end points are later merged with Mainline Inventory points
- allows data to be collected for those locations inaccessible to the Inventory Van - can also be used for roadside features

Remote Acquisition

- portable GPS receiver and ***laser rangefinder*** used to collect ***offset*** and XYZ coordinates for begin and end points of State Routes or portions of State Routes
- begin and end points are later merged with Mainline Inventory points
- allows data to be collected for those locations inaccessible to the Inventory Van - can also be used for roadside features

Data Processing Methods

- GPS Data Post Processing
- GPS - Inertial Navigation
Data Merge
- Roadtrack Editing

Data Processing is used to:

- increase accuracy of the GPS positions collected
- create an integrated file containing both Inertial Navigation and GPS data
- “smooth” the roadtrack points
- prepare a cartographic-ready file for creating GIS “smart road” layer with dynamic segmentation

Dynamic Segmentation

- GIS function that locates a point or line segment by interpolating the distance between two known points
- allows the recording of information along linear features
- location is given in terms of a known feature, e.g., “SR 004” and a position or measure on it
- this position is expressed in terms of SRMP or ARM

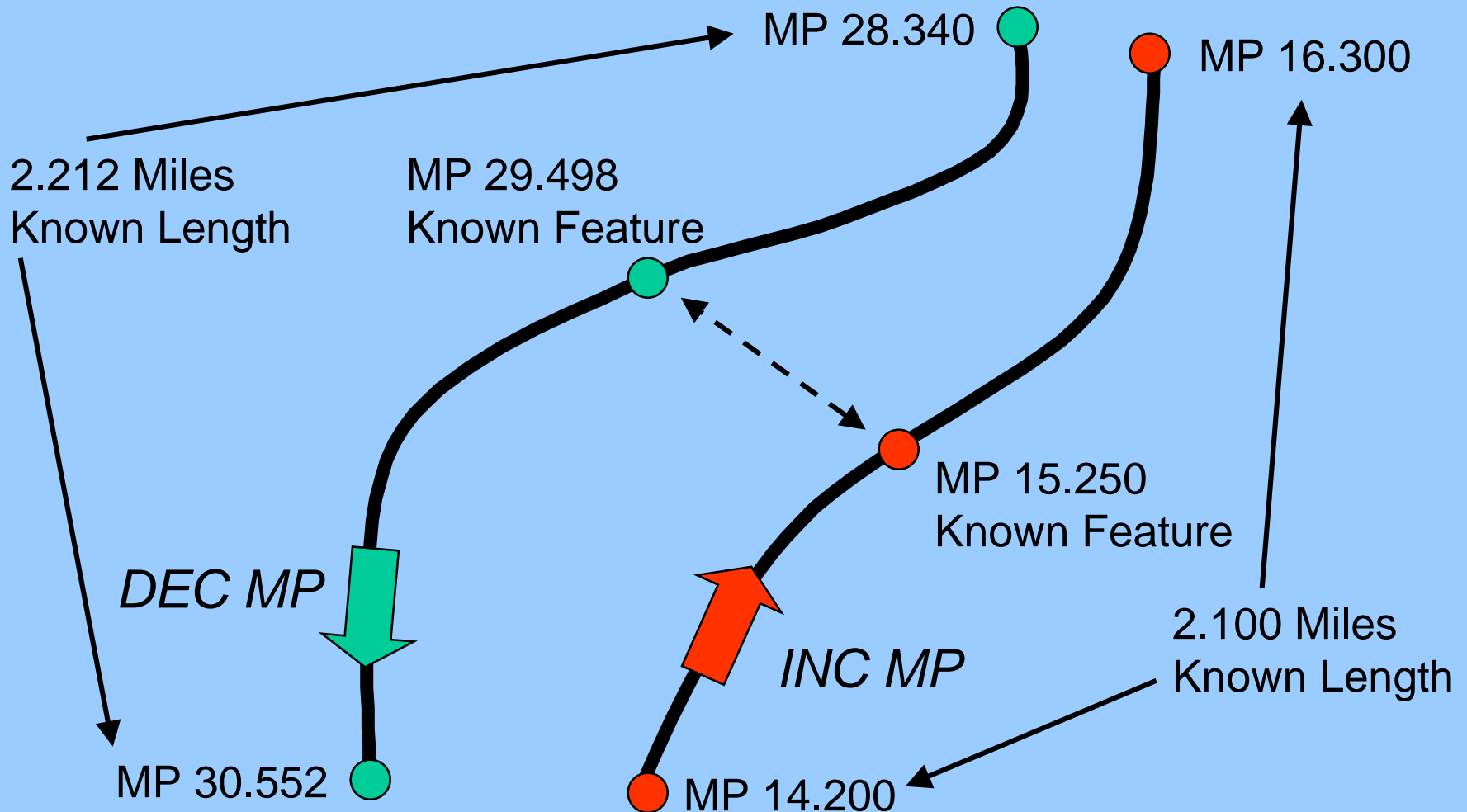
Recent Applications of Mainline Inventory

- Improves safety and efficiency of spring snow removal on mountain pass highways
- Enables crews to better find and stay within roadway boundaries when plowing, thus avoiding damage to guardrails

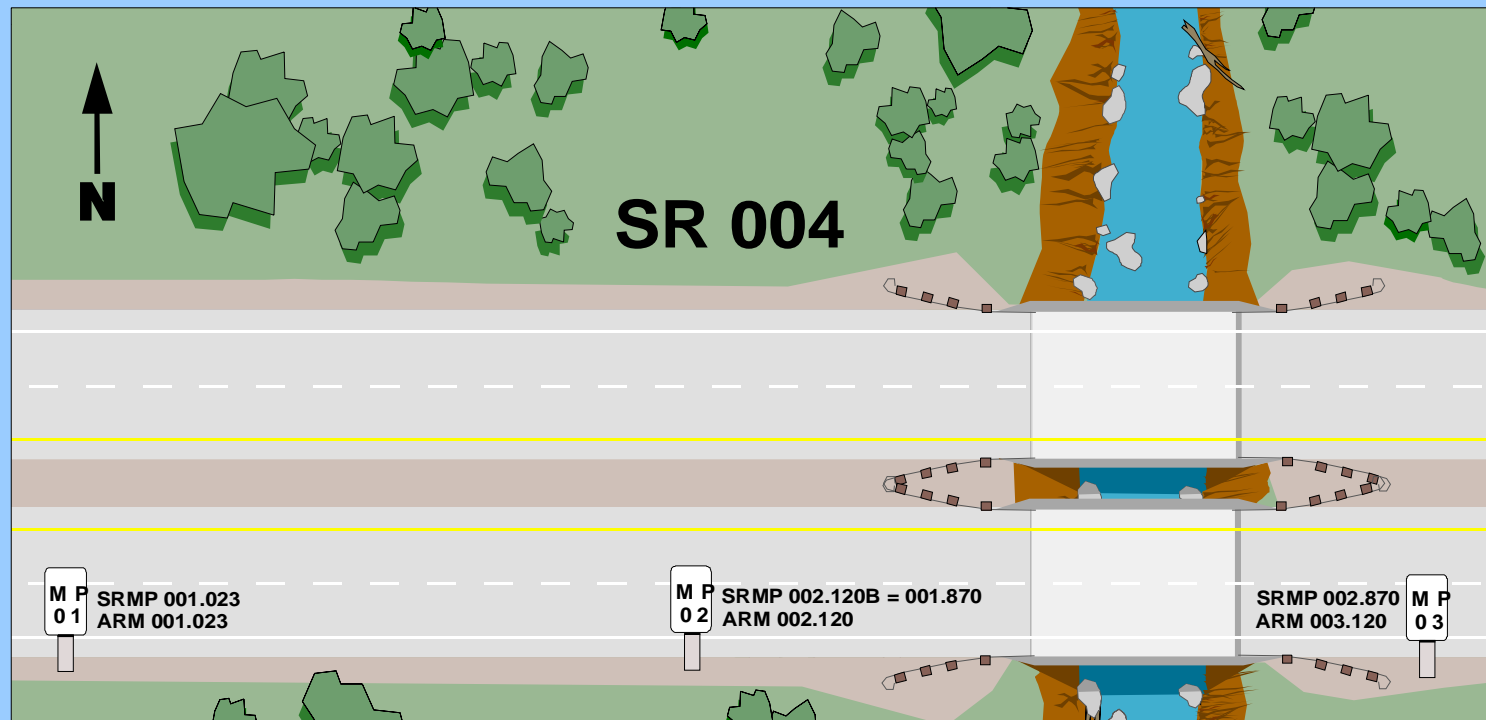
Components of Future WSDOT Linear Referencing System

- State Route (SR) Number
- State Route Milepost (SRMP)
- Accumulated Route Mileage (ARM)
- SRMP / ARM / GPS Interchangeable
- Direction of Inventory
- Left/Right Indicator
- State Route Back Mileage
- Equation (Back, Gap or Physical Gap)
- Coincident Mileage
- Related Roadway Type (RRT)
- Related Roadway Qualifier (RRQ)

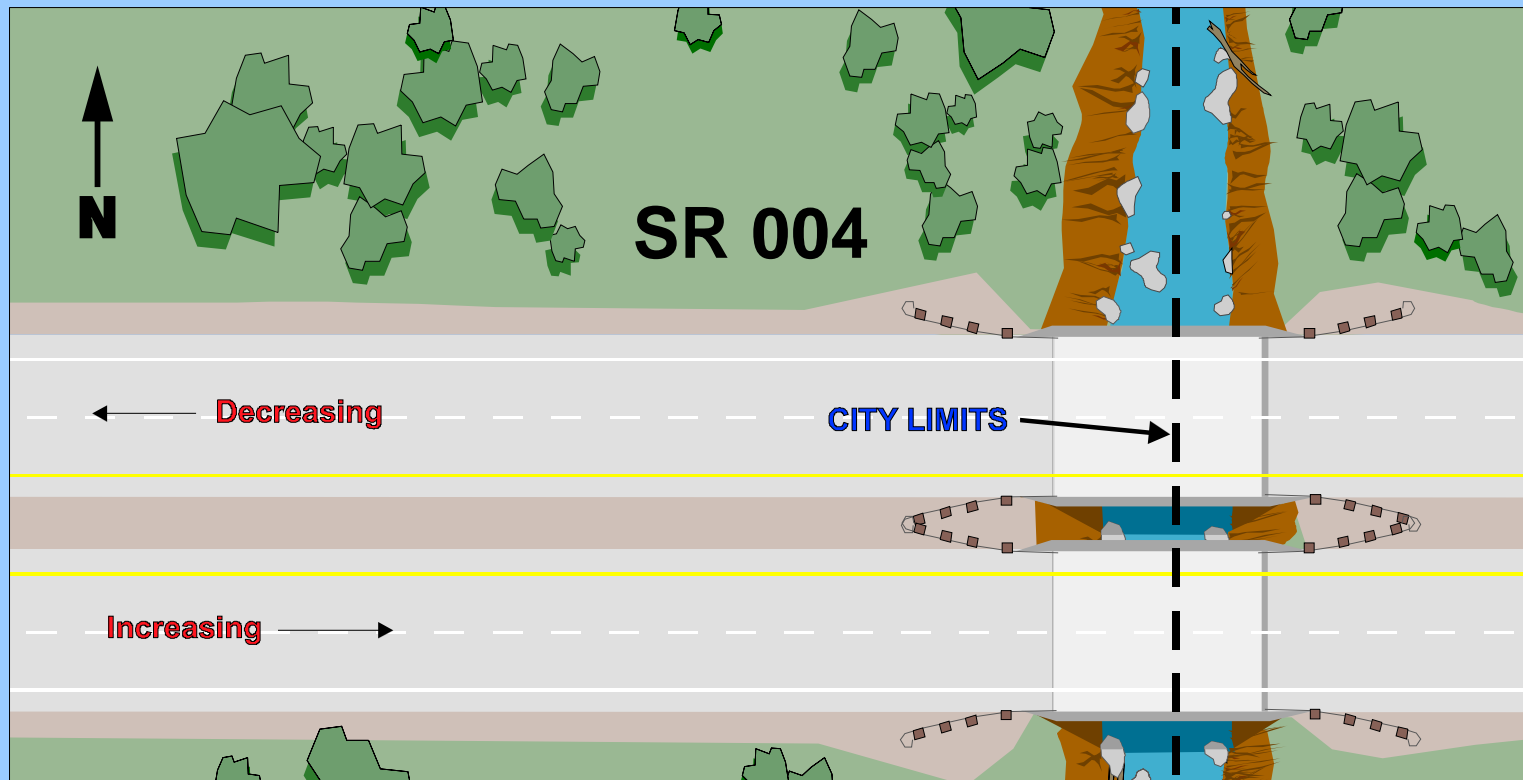
Divided Highway Offset with Future LRS



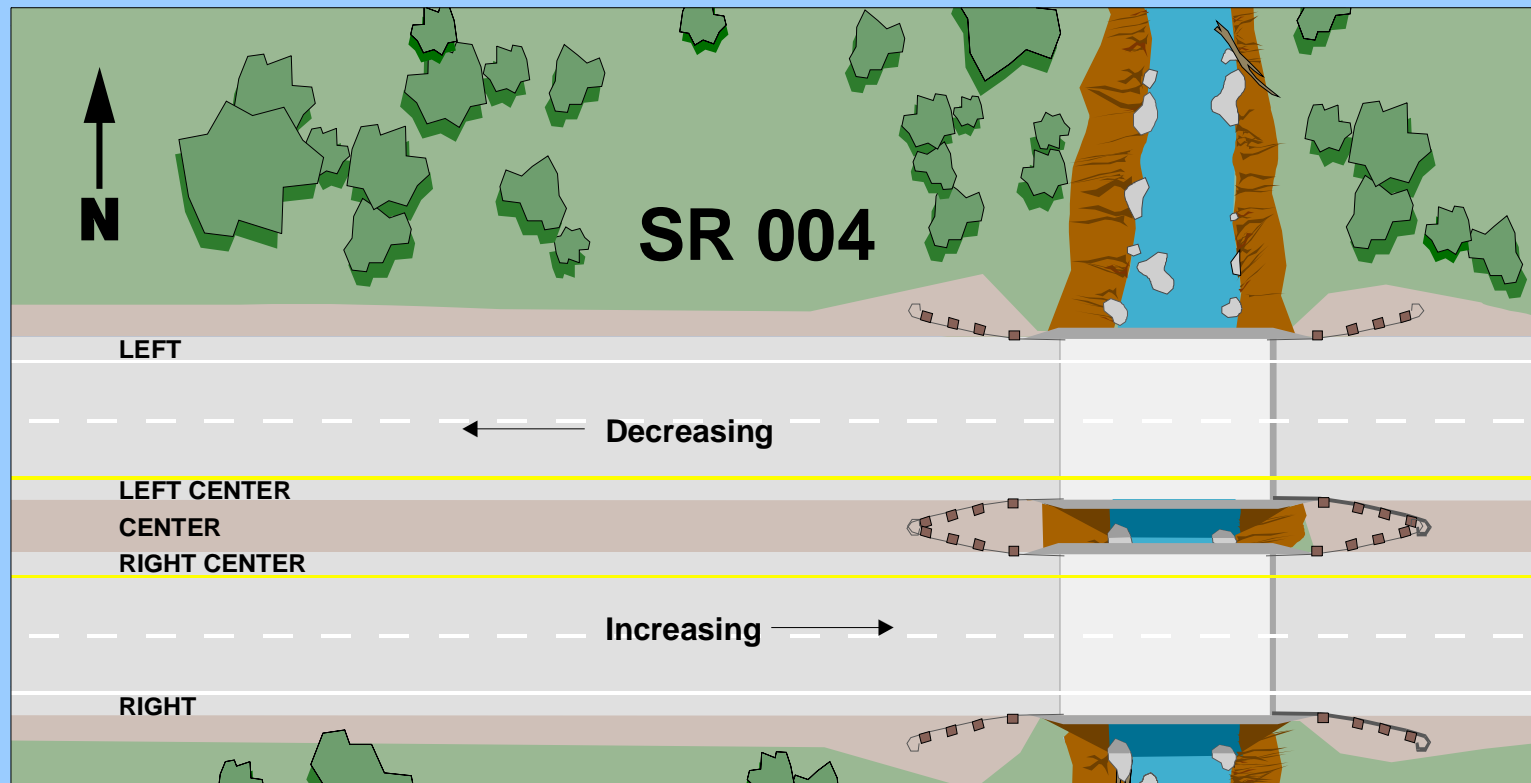
- SR Number - identified by three digit number
- SRMP - assigns a logical value to a given point along a route to the nearest thousandth of a mile (1.023); length adjusted with equations
- ARM - accrual of mileage from beginning to end of route; true physical length, no equations



- Direction of Inventory - used for features that occur ON the SR's main traveled way
- indicates if feature affects Increasing SRMP direction of travel, Decreasing SRMP direction of travel, or Both directions of travel

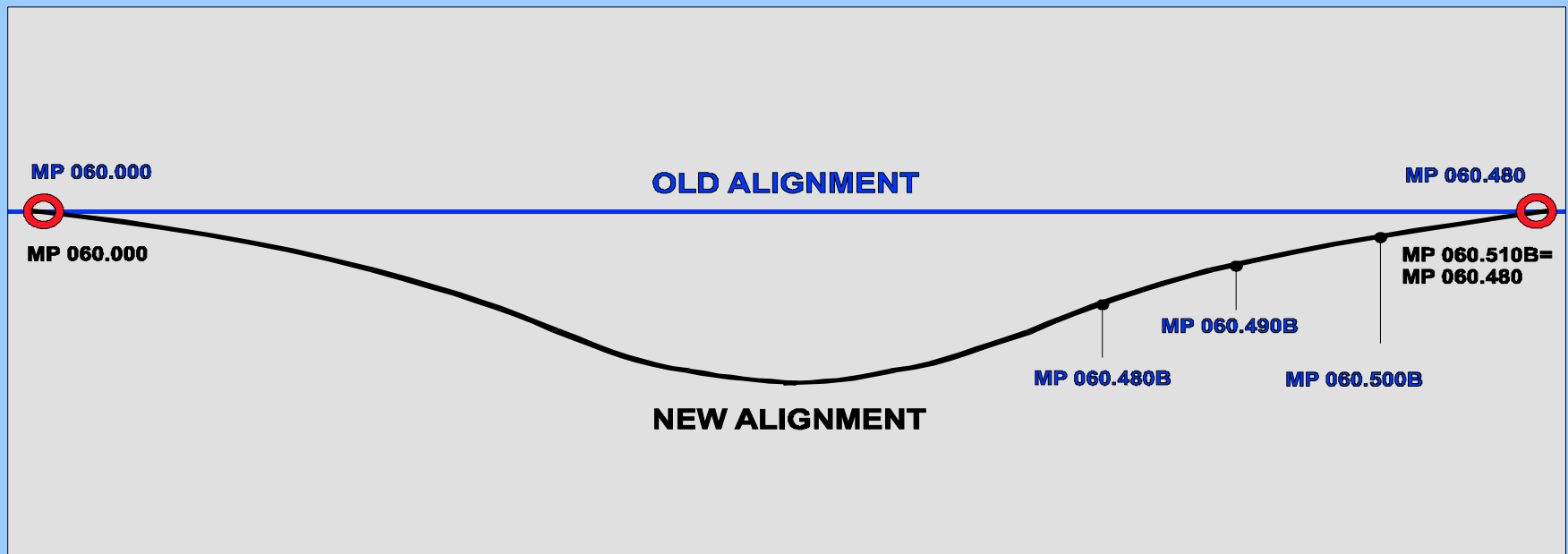


- Left/Right Indicator - used for features that occur **ALONG SIDE** the SR's main traveled way
- all Left/Right indicators are based relative to the Increasing SRMP direction of travel, starting from left side of the traveled way and working to the right

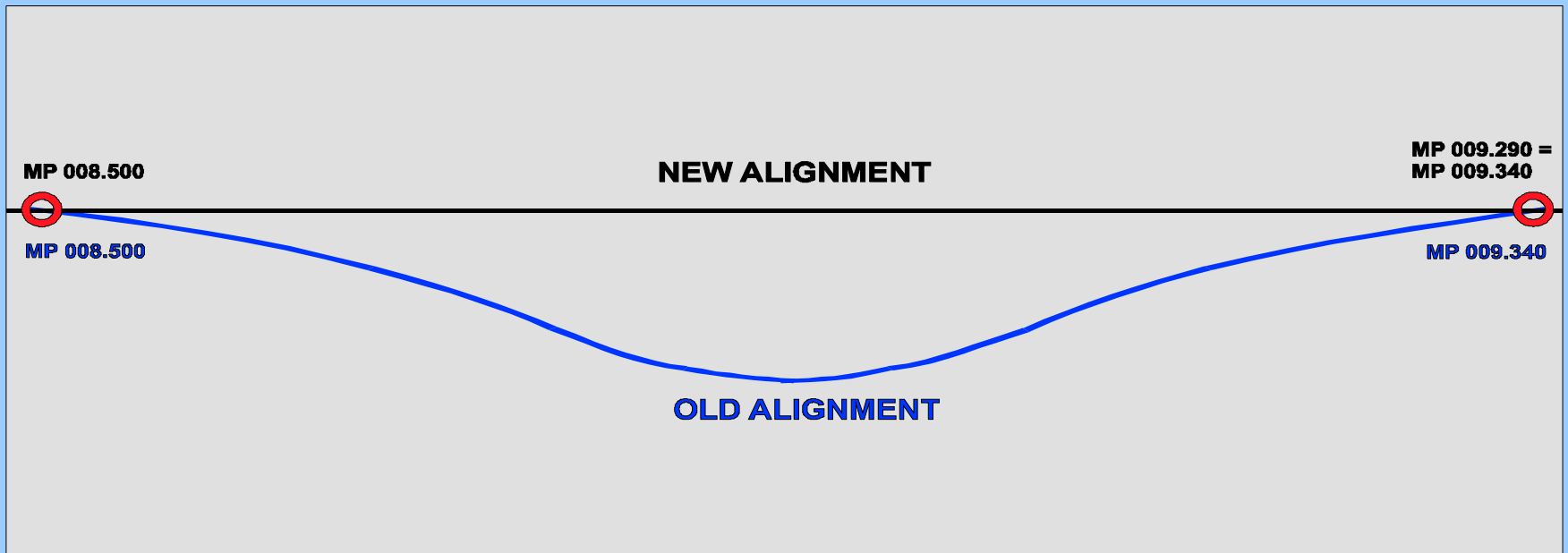


- SRMP Back Mileage - indicates if the milepost value is the duplicate (Back) of a milepost value on another portion of the State Route
- occurs as a result of realignment or adding mileage to the beginning of the State Route

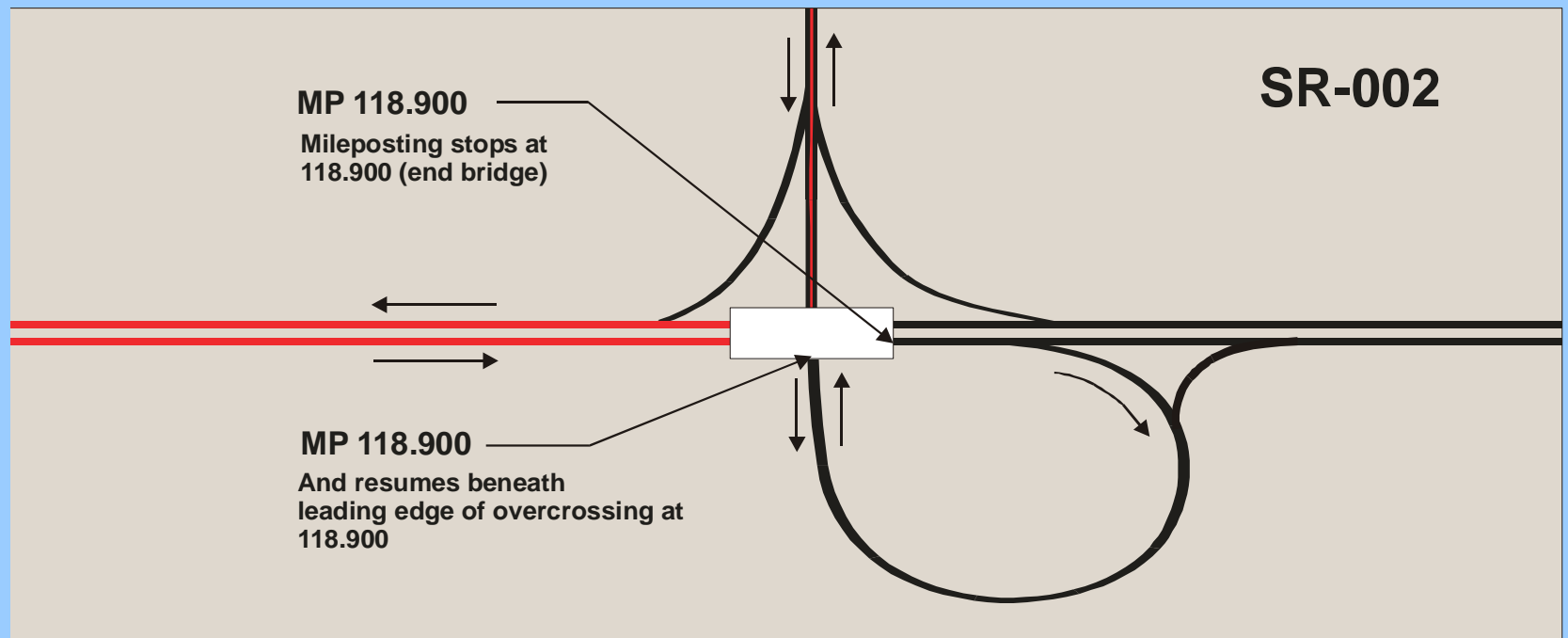
- Back Equation - used to adjust SRMP when a new alignment lengthens a section of State Route, e.g., SRMP 60.510B = 60.480
- the rest of the SRMPs for the route remain the same
- the ARM will adjust to accommodate the route's new length



- Gap Equation - used to adjust SRMP when a section of State Route is shortened other than at its end, e.g., SRMP 9.290 = 9.340
- the rest of the SRMPs for the route remain the same
- the ARM will adjust to accommodate the route's new length



- Physical Gap Equation - used to indicate a physical break in the continuity of a State Route
- often occurs when a designated State Route transfers from one portion of a limited access facility to another



- Coincident Mileage - occurs when two or more State Routes use the same physical alignment
- the SR with the higher functional class takes precedence
- if both SRs are the same class, the lower route number takes precedence

- Related Roadway Type (RRT) - two character abbreviation used to identify portions of the State Route system other than the main traveled way
- includes categories for alternate routes, couplets, spurs, frontage roads, on/off ramps, collector-distributors, interchange crossroads, reversible lanes and ferry terminals

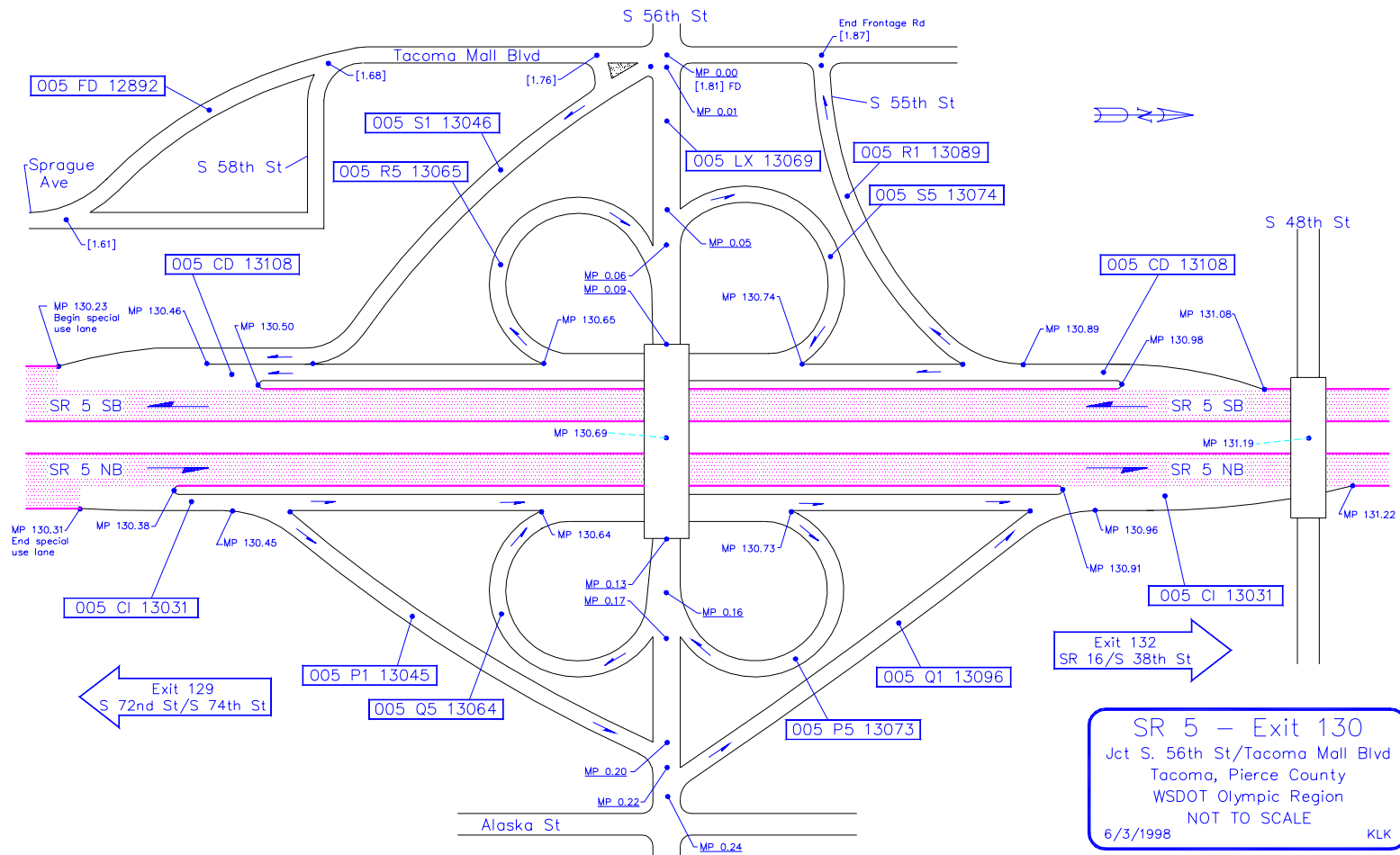
- Related Roadway Qualifier (RRQ) - six character field which is combined with the RRT to further locate it to a specific area
- the RRQ can be based on: (1) a descriptive location, such as the name of a street or city; or (2) the mainline SRMP at the point where the RRT begins or attaches to the mainline

SR # + RRT + RRQ

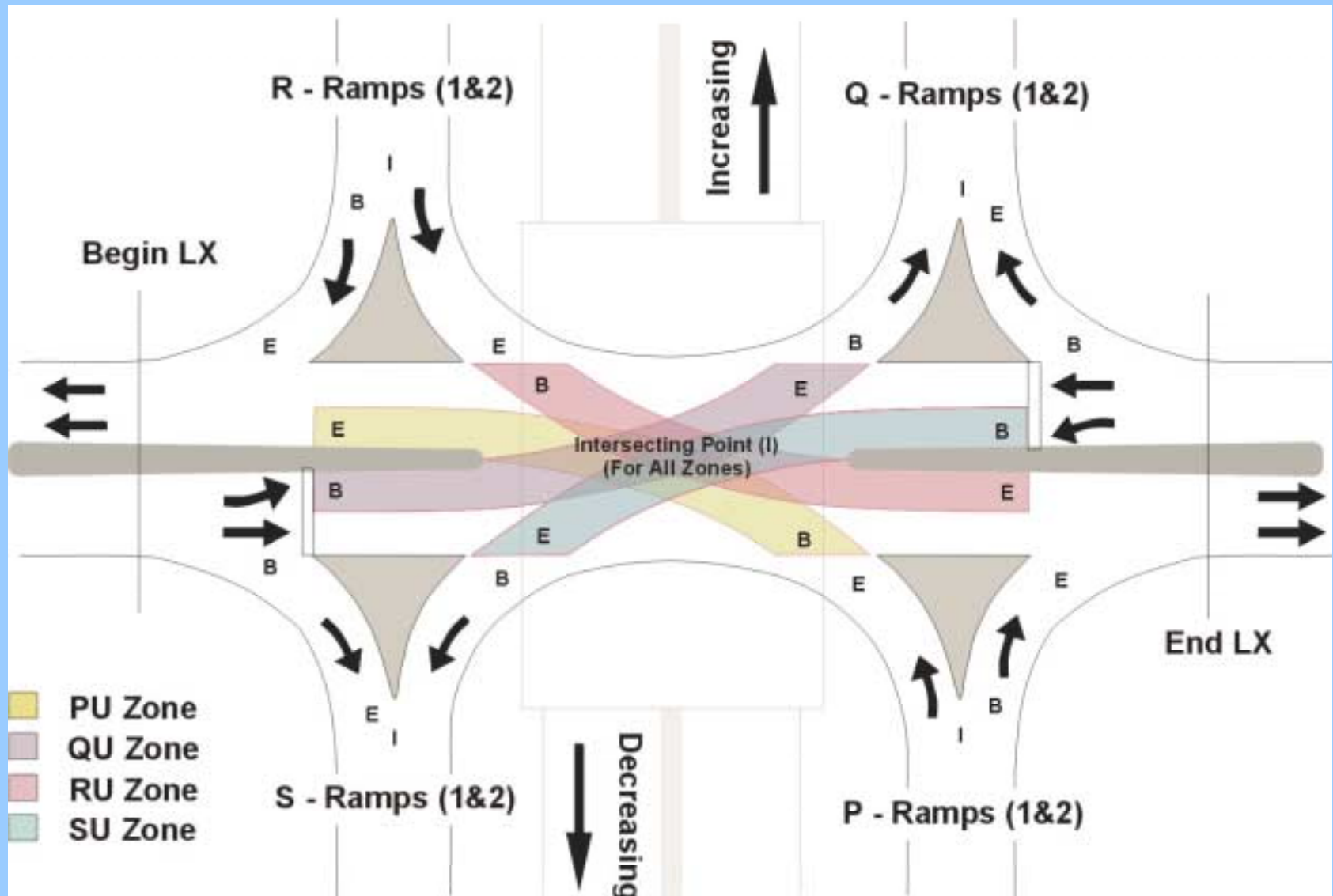
uniquely identifies each portion of the
State Route system:

- 101 CO ABERDN = SR 101 Couplet in Aberdeen
- 005 FD 08827 = SR 5 Frontage Rd on decreasing milepost side of mainline, beginning at SRMP 88.27
- 090 Q1 27254 = SR 90 On Ramp on increasing milepost side of mainline, ending at SRMP 272.54

Typical Diamond/Cloverleaf Interchange



Typical Single Point (Urban) Interchange



Currently, the following Linear Referencing Systems are linked:

- State Route Milepost
- Accumulated Route Milepost
- Township, Range, Section
- Mapping Level GPS (in progress)

Eventually these Linear Referencing Systems will also be linked:

- Milepost Stationing
- Survey Level GPS

Future Plans

- As resources permit, complete the GPS Mainline Inventory on the remaining State Routes
- Look for ways to streamline the office processing of data to reduce turnaround time
- Acquire GPS mapping grade equipment from Leica, the newly selected supplier for WSDOT
- Provide training to rest of WSDOT to ensure that consistent GPS data collection procedures are used throughout the department